Acute plant poisoning: analysis of clinical features and circumstances of exposure

Fuchs, J ; Rauber-Lüthy, C ; Kupferschmidt, H ; Kupper, J ; Kullak-Ublick, G A ; Ceschi, A

Abstract: INTRODUCTION: Human contact with potentially toxic plants, which may occur through abuse or by accident or attempted suicide, is frequent and sometimes results in clinically significant toxicity. OBJECTIVE: The aim of the present study was to identify which plants may lead to severe poisoning, and to define the clinical relevance of plant toxicity for humans in Switzerland. METHODS: We analyzed 42,193 cases of human plant exposure and 255 acute moderate, severe, and lethal poisonings, which were reported to the Swiss Toxicological Information Centre between January 1995 and December 2009. RESULTS: Plant contact was rarely responsible for serious poisonings. Lethal intoxications were extremely rare and were caused by plants with cardiotoxic (Taxus baccata) or mitosis-inhibiting (Colchicum autumnale) properties. CONCLUSIONS: Most often, plant contact was accidental and patients remained asymptomatic or developed mild symptoms, which fully resolved within a short time.

DOI: https://doi.org/10.3109/15563650.2011.597034

Acute Plant Poisoning: Clinical Features and Circumstances of Exposure

Joan Fuchs[a], Christine Rauber-Lüthy[a], Hugo Kupferschmidt[a], Jacqueline Kupper[a,c], Gerd A. Kullak-Ublick[b] and Alessandro Ceschi[a]

(a) Swiss Toxicological Information Centre (STIC), Zurich, Switzerland

(b) Department of Clinical Pharmacology and Toxicology, University Hospital Zurich, Switzerland

(c) Institute of Veterinary Pharmacology and Toxicology, Vetsuisse Faculty, University of Zurich, Switzerland

Corresponding author:

Alessandro Ceschi, MD
Head, Division of Science
Swiss Toxicological Information Centre
Freiestrasse 16
CH-8032 Zurich

Tel: +41-44-634-1034
Fax: +41-44-252-8833
e-mail: Alessandro.Ceschi@usz.ch

Abstract

Human contact with potentially toxic plants, which may occur in abuse or in an accidental or suicidal setting, is frequent and sometimes results in clinically significant toxicity. The aim of the present study was to identify which plants may lead to severe poisoning, and to define the clinical relevance of plant toxicity for humans in central Europe. By means of a retrospective case-study design, we analysed 42'193 cases of human plant exposure and 255 acute moderate, severe, and lethal poisonings, which were reported to the Swiss Toxicological Information Centre between January 1995 and December 2009. Plant contact was rarely responsible for serious poisonings. Lethal intoxications were extremely rare and were caused by plants with cardiotoxic (Taxus baccata) or mitose inhibiting (Colchicum autumnale) properties. Most often, plant contact was accidental and patients remained asymptomatic or developed mild symptoms, which fully resolved within a short time.

Keywords: Plants, toxicity, poisoning, accidental, abuse, suicidal, severe, lethal

1. Introduction

Human contact with potentially harmful plants is frequent. Plant exposures rank tenth in children and sixteenth in adults in the list of the exposures most commonly reported to poison control centres in the United States (Bronstein et al, Annual Report 2008), thirteenth (no age distinction) in Taiwan (Lin et al, 2009), second in children and sixth in adults in Germany (in combination with mushroom exposures; Zilker, Annual Report Giftnotruf München 2006/7) and third in children and sixth in adults in Switzerland (STIZ, Annual Report 2008).

Most plants are harmless to humans, but there are a few that can cause toxicity. There are three possible circumstantial settings leading to exposure to plants: accidental, abuse or suicidal. An abundance of literature has been published on accidental exposure to plants (Piccillo et al, 2002; Joshi et al, 2003; Minodier et al, 2003; Sundov et al, 2005; Fujita et al, 2007; Andreola et al, 2008; Grobosch et al, 2008; Pullela et al, 2008; Smith et al, 2008; Wasfi et al, 2008; Wollersen et al, 2009; CDC, 2010; Papoutsis et al, 2010;) and on abuse by ingestion of plants (Borsutzky et al, 2002; Göpel et al, 2003; De Frates et al, 2005; Diker et al 2007, Spina and Taddei 2007, Wiebe et al 2008), while literature on suicidal exposure is limited (Danel et al, 2001; Willaert et al, 2002; Bourgeois et al, 2005; Pietsch et al, 2007; Gottignies et al, 2009). Most of these articles are case reports or small case series. There are only a few studies investigating the epidemiology of human exposure to plants (Jaspersen-Schib et al, 1996; Lamminpää and Kinos, 1996; Isbister et al, 2003; Vichova and Jahodar, 2003; Srivastava et al, 2005; Forrester, 2006; Pietsch et al, 2008; Krenzelok, 2010), and these publications indicate that accidental exposure is the most frequent circumstance of poisoning, closely followed by abuse. Therefore, we performed a retrospective study to investigate the epidemiology of plant exposures in Switzerland with a focus on the three settings listed above, and to elucidate which plants are mainly responsible for cases of moderate, severe, and fatal poisoning.

We analysed all cases of acute human exposure to potentially toxic plants reported to the Swiss Toxicological Information Centre (STIC) by the general public and healthcare professionals in a first part, and, in a second part, all well-documented cases of acute mono-intoxications with plants reported by physicians. The study period was between January 1995 and December 2009. The aim of this study was to define the clinical relevance of plant toxicity for humans in central Europe and to

identify which plants may actually lead to severe poisoning, with a view to improving prediction of the expected clinical course of acutely intoxicated patients and avoiding unnecessary hospital admissions.

2. Methods

2.1. Data acquisition

A retrospective case-study design was used. The STIC provides 24-hour 7-days-a-week nationwide free medical advice in cases of poisoning to health professionals and the general public. The referral population is about 7.8 million people. Demographic and detailed clinical information on exposure cases - such as age (children defined as < 16 y), sex and weight of the patient, circumstances of exposure/poisoning, ingested quantities of all plants involved, co-ingestions (such as medications, alcohol), symptoms, and causality - are recorded in a systematic and standardized manner by a physician trained in clinical toxicology and blinded to any study hypotheses at the time of the initial phone call. These data are prospectively entered into an in-house structured electronic database (TOXI; Liechti and Kupferschmidt, 2004). For reports by health care professionals, the STIC collects additional specific clinical data – including complementary information on type and, if applicable, dose of the substances ingested (analytical toxicology), current history and circumstances of substance intake, observed symptoms and signs including heart rate and blood pressure, Glasgow Coma Scale (GCS) score, an electrocardiogram, therapeutic interventions and any decontamination procedures performed, latency to decontamination, observed clinical course, and eventual medical complications - using a standardized report form which is sent to the treating physician. Hospital physicians are also asked to provide a discharge letter and any laboratory results, as well as the results of other examinations. This follow-up information is then matched with the data taken during the initial call and entered into the database to complement the case files. Each case is reviewed by a senior clinical toxicologist to ensure completeness and correctness of entered data before finalizing recording into the database.

2.2. Inclusion criteria

The following criteria had to be met for reported cases to be included in the study:

a) for the analysis of exposure:

- enquiries between January 1995 and December 2009;
- enquiries by the general public and health care professionals;
- acute human exposure;
- exposure to one or more plants;

b) for the analysis of symptoms, severity and outcome:

- enquiries by physicians only
- presence of written feedback from the treating physicians with sufficiently detailed data about symptoms and evolution;
- acute human mono-intoxications;
- plant must be identified by a specialist (gardener, pharmacist or specially trained personnel of the Poison Control Centre) by its botanical name;
- moderate, severe or lethal outcomes;
- confirmed or likely causal relationship between exposure and clinical effect. Causality assessment is based on a clear temporal relationship between plant exposure and symptoms, absence of drugs or diseases that can explain the symptoms, and the presence of symptoms, which are described for the plant in question. Since these criteria cannot be used for asymptomatic patients, these cases are judged only according to the contact with the plant as reported by the patient or by relatives. Analytical detection of a specific toxin in a body fluid defines a case as confirmed.

2.3. Exclusion criteria

- Phytomedicines (industrially processed plant materials like tinctures, mixtures and teas);
- Industrial botanical ingredients and foodstuffs;

- Nicotiana tabacum (Tobacco) was excluded because of industrial processing of plant material;
- Cannabis sativa was excluded because the distinction between plant (marihuana) and resin (processed product, hashish) was frequently not possible.

2.4. Severity assessment

According to the Poisoning Severity Score (PSS) developed by the European Association of Poison Centres and Clinical Toxicologists, the WHO International Programme on Chemical Safety (IPCS) and the European Commission (Persson et al, 1998), the severity of symptoms of individual patients were classified as 'minor' if only minor symptoms were present, as 'moderate' if at least one moderate symptom developed, as 'severe' if at least one severe symptom was observed, or as fatal. A summary of symptoms according to their severity is shown in Table 1.

2.5. Statistical evaluation

Statistical analysis for descriptive statistics was performed using SPSS software (Version 17.0; SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Human exposures to toxic plants

During the 15 years study period the STIC recorded a total of 427'107 cases of human exposures to different toxic agents or substances. 42'193 (9.9%) were exposures to potentially toxic plants or plant material. The annual number of human exposure to toxic plants ranked from 2516 to 3287, with a tendency to increase in recent years. Children were involved in 34'014 (80.6%) of all cases. Although 639 plant genera were involved in total, the vast majority of cases (30'499 calls, 72.3%) were due to 50 plant genera/plant parts (Table 2). Unspecified berries ranked at the top of the list of enquiries, closely followed by *Prunus*, *Ficus,* and *Taxus*. Exposure was accidental in 29'770 cases, abuse in 417, and suicidal in 219 cases. In the accidental exposure setting, the most frequent plant genera beyond unspecified berries, were *Prunus* sp. (n= 2756) in children, and *Euphorbia* sp. (n= 687) in adults.

In abuse, *Datura* sp. (n= 290) was the most common plant, and *Taxus* sp. (n= 61) was the most frequently used plant for suicide attempts.

3.2. Symptoms, severity and outcome

Among all cases concerning medically relevant exposure to toxic plants that were reported to the STIC during the study period, written follow-up information was provided in 1900 cases (4.5%). Of these 1471 (77.4%) were asymptomatic or mild cases and were therefore not included in the study. Of the remaining 429 cases (364 moderate, 57 severe and 8 fatal), 158 moderate, 12 severe, and 4 fatal cases had to be excluded because of insufficient causality, leaving 255 cases (206 moderate, 45 severe, and 4 fatal), which were further analysed. The demographic characteristics of these patients were as follows: there were 147 (57.6%) males and 95 (37.3%) females. In 13 cases gender was not specified. The age of the patients ranged from 2 months to 94 years, with a mean of 28 years, and a median of 22 years. Children were involved in 58 (22.8%) cases. In 26 cases the age (in years) could not be determined, but the attribution to an age-group (child/adult) was possible.

Forty-eight different plants were responsible for the acute moderate, severe or lethal poisonings observed in this study. *Datura* (also known as *Brugmansia*) *suaveolens* and *stramonium* (Angel's Trumpet and Jimsonweed) were at the top of the list with 75 (29.4%) cases, followed by *Atropa belladonna* with 31 (12.2%), *Euphorbia* with 24 (9.4%), and *Heracleum mantegazzianum* with 17 (6.7%) cases.

3.2.1. Symptoms observed in moderate, severe and fatal poisonings

We could determine five groups of plants as being responsible for moderate, severe and lethal outcomes: plants of abuse (with anticholinergic properties), cardiotoxic plants, plants with mitose inhibiting properties, plants with gastrointestinal toxicity, and plants with skin or eye toxicity.

The most frequently reported symptoms for the 116 patients who ingested plants of abuse (*Datura* sp., *Atropa belladonna,* and *Argyreia nervosa* as the most common) were mydriasis (88 cases, 75.8%), hallucinations (75 cases, 64.6%), and tachycardia (71 cases, 61.2%). The most commonly observed symptoms in the 19 patients who ingested cardiotoxic plants (e.g. *Aconitum napellus*, *Taxus baccata*, *Veratrum album*,

Nerium oleander, *Laburnum anagyroides,* and *Helleborus viridis*) were vomiting (15 cases, 78.9%), hypotension (8 cases, 40.1%), and bradycardia and arrhythmias (7 cases each, 36.8%). The six patients having ingested the mitose inhibiting plant *Colchicum autumnale* most frequently showed vomiting (5 cases, 83.3%), diarrhea, elevation of serum alkaline phosphatase (3 cases each, 50%), disturbances of blood coagulation and metabolic acidosis (2 cases each, 33.3%). Of the 53 patients who were exposed to plants with phototoxic or direct irritant effects (such as *Euphorbia* sp., *Heracleum mantegazzianum,* and *Dieffenbachia* sp.), skin and corneal lesions were observed in 29 (54.7%) and 26 (49%) cases respectively. The most common symptoms reported in the group of 59 patients who ingested plants with gastrointestinal toxicity (*Cucurbita pepo*, *Phaseolus vulgaris*, *Wisteria floribunda*, *Allium ursinum*, *Ricinus communis*, *Phytolacca americana,* and *Lycopodium clavatum* as the most frequent) were vomiting (38 cases, 64.4%) and diarrhea – bloody in some cases – (26 cases, 44.1%).

Of the 255 cases analysed in this study, 250 (98%) had a full recovery, one (0.39%) developed permanent visual impairment (after ocular exposure to corrosive *Euphorbia* plant sap), and four cases (1.57%) were fatal.

3.2.2. Outcome

All 206 patients with moderate symptoms required medical care but could be discharged without sequelae. Despite the fact that data on the length of hospitalisation was not available in all cases (no information in 33 cases), patients with moderate symptoms could be discharged after a maximum of 12 days, with a median hospitalisation time of 1 day (mean = 1.9 days). 80 moderate cases did not require hospitalisation and could be discharged after treatment as outpatients. The length of hospitalisation for severe and lethal cases was similar (information about length of stay available for 43 out of 49 severe and fatal cases) and ranged between ambulatory visits (2 cases) to a stay of 8 days (one case) with a median hospitalisation time of 2 days (mean = 2.2 days).

The ranking of plants causing moderate symptoms is shown in table 3. The severe and fatal cases are listed in detail in table 4 with information about responsible plants, symptoms, treatments, and outcome.

3.2.3. Fatal cases

All fatal poisonings were caused by plants with cardiotoxic or mitose inhibiting effects. A nearly 3-year-old boy died of cardiac, respiratory and hepatic failure after ingestion of *Colchicum autumnale* (colchicine serum concentration 7 µg/l, toxic > 5 µg/l). Another fatal ingestion of *Colchicum autumnale* occurred in a 62-year-old man, who had mistaken it for *Allium ursinum* (wild garlic). He initially developed gastrointestinal symptoms (prolonged vomiting, diarrhea) and subsequently died of acute renal failure, coagulopathy, and myocardial necrosis. The third lethal *Colchicum* poisoning, also due to confusion of *Allium ursinum* with *Colchicum autumnale*, concerned a 57-year-old woman presenting with profuse diarrhea, vomiting, respiratory failure due to pulmonary oedema, hepatic failure, acute renal failure, and subsequently developing severe hypotension and asystolia. The last fatal case was due to the ingestion of the cardiotoxic plant *Taxus baccata* in a 43-year-old woman who had deliberately ingested an unknown amount of the *Taxus* needles and presented with vertigo. She refused all decontamination measures and quickly deteriorated showing alteration of consciousness and circulatory failure due to dysrhythmias (bradyarrhythmias, torsades de pointes, and asystolia). Digoxin-specific antibody fragments (Eddleston et al., 2003) were not administered due to logistic problems.

3.3. Circumstances of exposure

3.3.1. Accidental exposure

Of the 255 cases included in the study, 134 (52.5%) were due to accidental exposure: 81 concerned adults (41.1% of the 197 adult cases), and 53 concerned children (91.4% of the 58 paediatric cases). Most frequently adults either had accidental dermal or ocular contact with *Euphorbia* sp. (18 cases, 23.4%) or accidentally ingested *Cucurbita pepo* (12 cases, 15.6%), *Atropa belladonna* (6 cases, 7.8%), and *Allium ursinum* and *Phaseolus* sp. (4 cases each, 5.2%). Children either had accidental dermal contact with *Heracleum mantegazzianum* (14 cases, 26.4%) or accidentally ingested *Datura* sp. (8 cases, 15.1%), *Euphorbia* sp. (6 cases, 11.3%), and *Atropa belladonna*, *Phaseolus* sp., and *Wisteria floribunda* (each 4 cases, 7.5%).

3.3.2. Abuse

Of the 255 poisonings which were included in this study, 103 cases (40.4%) concerned abuse by consumption of plants: 98 adults (49.7%) but only five children (8.6%) presented to a healthcare facility with moderate to severe symptoms following abuse by ingestion. The five symptomatic children were mostly in their mid-teens (all were 15, with one exception of a 12 years old boy) and all had ingested *Datura* sp. Adults most commonly ingested *Datura* sp. (53 cases, 51.4%), *Atropa belladonna* (9 cases, 8.7%), and *Argyreia nervosa* (4 cases, 3.9%). Other plants consumed for abuse included *Mandragora officinalis* (2 cases) and *Hyascyamus niger*, *Ipomoea* sp., and *Papaver somniferum* (1 case each). For an overview of *Datura* and *Atropa* abuse analyzed by gender, age and plant, irrespective of severity of symptoms, see figure 1.

3.3.3. Suicidal intention

Of the 255 poisonings included in this study, 18 (7.1%) adult patients were brought to the emergency department after intentional self-poisoning with toxic plants. Five (27.7%) cases of ingested *Aconitum napellus* led the ranking, closely followed by *Taxus baccata* in four (22.2%), and *Atropa belladonna* in three (16.6%) cases.

4. Discussion

This study is a follow-up project after a first large plant poisoning study in Switzerland (Jaspersen-Schib et al, 1996). In the current study plant exposures were only rarely responsible for major symptoms, considering the large number of enquiries. Most often, exposure was accidental and thus, since it can be supposed that only small quantities of plant material were ingested, outcomes were mostly asymptomatic or mild, and the patients experienced a full recovery even in cases with moderate or severe symptoms (with one exception of permanent visual impairment after ocular contact with highly irritating *Euphorbia* plant sap). However, since small doses of highly toxic plants can suffice for severe symptoms (Wasfi et al 2008), severe and fatal poisonings could also be observed in the accidental setting, as confirmed by the three fatal poisonings after accidental ingestion of Colchicum autumnale. Our observations are compatible with those reported in the literature (Jaspersen-Schib et

al, 1996; Lamminpää and Kinos, 1996; Isbister et al, 2003; Vichova and Jahodar, 2003; Srivastava et al, 2005; Forrester, 2006; Pietsch et al, 2008; Krenzelok, 2010).

Overall, most enquiries concerned children. In paediatric plant ingestions, unidentified berries and plants prevail, the reason for this being that identification was not forced if highly toxic plants (such as *Atropa*, *Aconitum*, *Nerium*, *Colchicum*) could be excluded by description and no major symptoms were observed or expected. In recent years electronic devices have helped to simplify plant identification procedure. For example, in some of our cases, a picture by digital camera or cellular phone was sent by email or MMS to the Poison Centre and was then identified by a qualified person, as has been previously described (Lurie et al, 2008).

There were remarkable differences in the pattern of plant poisoning depending on the circumstances of exposure (accidental, abuse or suicidal): in accidental poisoning, which was the most frequent type of exposure to potentially toxic plants in both genders and typically concerned children, unidentified berries of all colours, and identified berries (*Prunus*, *Taxus*, *Convallaria,* and *Lonicera* among others), were most frequently involved, indicating that berries pose a great temptation to children. Typical routes of accidental exposure are ingestion or eye or skin contact. The immaturity of ingested berries has been described as a cause for major gastrointestinal symptoms (Barceloux, 2008; Smith et al, 2008). Another way of accidental poisoning, more frequent in adults, is the ingestion of raw beans or gourds with subsequent vomiting and diarrhea, sometimes haemorrhagic (Haidvogel et al, 1997; Philip and Lichius, 2005).

Abuse of plant parts ranked second in frequency, both in men and women, with *Datura* sp. being the most frequently involved. Typical patients were adolescents and young adults, with a clear male predominance, which is in accordance with previous studies on common drugs of abuse (Carstairs and Cantrell, 2010). Social and cultural factors, e.g. educational background, unemployment and ethnicity (Galea et al, 2004), may at least partially explain the observed differences between genders. In some cultures Solanaceae have been used to induce hallucinations for rituals or as herbal medications for over 4000 years (Teuscher and Lindequist, 1994; Papoutsis et al, 2010). Also, even though it is now more socially acceptable for girls and women to consume drugs (Zilberman et al, 2003), with a clearly decreasing mean age for first

contact, young men still have much easier access to drugs of abuse than women (Tuchman, 2010).

Other than in accidental exposure, the ingestion of plants with suicidal intent was exclusively performed by adult patients and concerned two groups of plants: those with cardiotoxic effects such as *Nerium oleander*, *Aconitum napellus* or *Taxus baccata*, and those with mitosis inhibiting properties such as *Colchicum autumnale*. However, fatal outcome after deliberate self-poisoning with plants was rare in our study. In contrast, this is a significant problem in some developing parts of the world, for example South Asia, where the ingestion of yellow oleander seeds with suicidal intent results in significant morbidity and mortality (Bandara et al, 2010; Eddleston and Warrell, 1999; Eddleston and Persson, 2003).

The frequencies of the three circumstantial settings of exposure – accidental as the most frequent, followed by deliberate abuse and suicidal intent – is in accordance with the findings in another study (Pietsch et al, 2008).

Although the number of plant species and genera which the patients in our study were exposed to is vast, we were able to identify three main mechanisms of toxicity responsible for the most serious effects: anticholingeric properties, mitose inhibiting, and cardiotoxic effects. Plants with anticholinergic effects - the family of the Solanaceae including *Datura* sp. and *Atropa belladonna* most frequently involved - were most commonly ingested for deliberate abuse. The symptoms observed in these patients were typical, with a predominance of tachycardia, mydriasis, and hallucinations (Frohne and Pfänder, 2005; Wiebe et al, 2006; Kupper and Reichert, 2009; CDC, 2010; Krenzelok, 2010). The mitose inhibiting plant *Colchicum autumnale* was responsible for 3 out of 4 of our lethal cases, causing a syndrome of multi-organ failure due to the direct toxic effect of colchicine on tissues with rapid cell turnover including gastrointestinal mucous membranes and the bone marrow (Mullins et al, 2000; Sundov et al 2005; Wollersen et al, 2009; Finkelstein et al, 2010). Colchicine poisoning has a high morbidity and mortality, and accidental ingestion of *Colchicum autumnale* leaves is unfortunately a common problem (Sundov et al, 2005) due to the possible confusion with *Allium ursinum*. Plants with cardiotoxic effects were responsible for one fatal (with *Taxus baccata*) and multiple severe cases in this study. Very small doses, i.e. one leaf, of these plants are sometimes sufficient for severe or fatal outcomes (Wasfi et al, 2008; Strzelecki et al, 2010). The leading

symptoms observed in these patients, such as bradycardia and asystolia (Teuscher and Lindequist, 1994; Kimura et al, 1997; Mullins et al, 2000; Willaert et al, 2002; Pietsch et al, 2005), are mainly due to two mechanisms: first, the inhibitory effect exerted by different alkaloids (e.g. aconite, oleandrine, protoveratrine (from *Veratrum album*), cytosine (from *Laburnum*) or helleborine) on the cellular sodium and potassium transport by binding to the Na,K-ATPase with consequently decreased resting potential of the cardiomyocytes and resulting proarrhythmogenic effect, and second, the blockage of sodium and calcium channels in cardiac myocytes, which has a negative inotropic effect (Frohne and Pfänder, 2005; Handeland, 2008).

Plants with moderate phototoxic or direct irritant effects like *Heracleum mantegazzianum* and *Euphorbia* sp., and plants causing mainly gastrointestinal toxicity like raw beans or ornamental gourds, were often ingested accidentally. The main pathophysiological mechanism for the plants causing skin and corneal lesions is a direct irritant effect. However, *Heracleum mantegazzianum* deserves separate consideration, as its furocoumarines have only a minor direct effect, but may cause severe phototoxic reactions in combination with UV light of a wavelength of 320-365 nm because of binding to the cellular DNA, which leads to a light-dependent destruction of the cell membranes (Musajo and Rodighiero, 1970; Teuscher and Lindequist, 1994). The group of plants with gastrointestinal toxicity due to direct irritant effects on the gastrointestinal tract mucosa had the greatest variety of different species.

A recent German study (Pietsch et al, 2008) identified the greatest endangering potential (likelihood for major symptoms after contact) for children to be with plants like *Brugmansia suaveolens* (*Datura suaveolens*, Angel's Trumpet), *Laburnum anagyroides*, *Phaseoulus vulgaris,* and *Thuja occidentalis*. This is in good accordance with our paediatric cases where we found that *Heracleum*, *Datura*, *Phaseolus*, *Euphorbia*, *Wisteria,* and *Atropa* were the plants most frequently responsible for major toxicity, whereas *Laburnum anagyroides* (two cases) and *Thuja occidentalis* (one case) only caused moderate symptoms in our patients. The most frequent plant genera in human exposure that were identified in our study matched the frequency of plant genera in the German study, the list being headed by *Prunus*, *Ficus,* and *Taxus*, even though the order was slightly different. The plant species we identified as being frequently involved in cases of human poisoning are similar to

those reported in a previous study performed in Switzerland (Jaspersen-Schib et al, 1996).

Average length of hospital stay was short – about two days – even in severe plant poisoning. However, length of stay is not always a good measure of severity, and information about hospitalisation time was lacking in many cases, and in others it was difficult to precisely determine, because the number of hospitalisation days sometimes included not only the time in the acute hospital setting, but also the stay in the psychiatric wards for suicidal patients. Other patients were discharged before complete recovery.

4.1. Limitations

Our study has several limitations. First, data from poison centres are considerably subject to reporting bias. In addition, the interpretation of our findings is limited by the retrospective analysis of cases despite the systematic prospective data collection. The treating physicians may not have mentioned all symptoms or laboratory data from their patients, and underreporting of cases with no or only minor toxicity likely occurred. Furthermore, laboratory confirmation was not available in most cases. However, to minimize misclassification in case of missing laboratory data, we included only cases where the causal relationship between plant exposure and clinical effect was at least likely. Another important limitation is the difficulty to determine the quantity of toxin the patient had been exposed to, because leaves or seeds of the same plant species may contain variable amounts of toxins, depending on vegetation period, soil, exposure to light, and age of the plant.

Our strict inclusion/exclusion criteria, in particular the decision to only include mono-intoxications and to exclude industrially processed plant materials (e.g. phytomedicines, industrial botanical ingredients and foodstuffs, *Nicotiana tabacum* and *Cannabis sativa*), led to small case numbers. However, we are convinced that these restrictions were necessary in order to be able to interpret the findings properly, in particular since in most cases we were not able to obtain analytical confirmation through detection of plant toxins. Similar limitations applying to poison centre data have been previously described (Hoffman, 2007).

5. Conclusions

Despite the heterogeneity of plants and patients included in this study, we could establish three groups of plants (anticholinergic, cardiotoxic, and mitose inhibiting) that are mostly responsible for severe poisoning, and the symptoms shown by the patients were characteristic for the corresponding plant species. In view of the high number of exposures with plants that showed only mild symptoms, and the very few cases with severe symptoms, serious poisoning from plants seems to be a very rare event in central Europe. Nevertheless, even accidental ingestions can be responsible for fatal poisonings. In most cases long-term follow-up and monitoring is unnecessary, because a full resolution of symptoms with no substantial sequelae can be expected within a short time.

Acknowledgement

None.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

The present work was supported entirely by the internal resources of the Swiss Toxicological Information Centre.

References

1. Andreola B., Piovan A., Da Dalt L., et al, 2008. Unilateral mydriasis due to Angel's Trumpet. Clin. Tox. (Phila). 46(4), 329–331.
2. Bandara V, Weinstein SA, White J, et al, 2010; A review of the natural history, toxinology, diagnosis and clinical management of Nerium oleander (common oleander) and Thevetia peruviana (yellow oleander) poisoning. Toxicon;56(3):273-81
3. Barceloux D.G., 2009. Akee fruit and Jamaican vomiting sickness (Blighia sapida Köenig). Dis. Mon. 55(6):318-26. Review
4. Bourgeois B., Incagnoli P., Hanna J., et al., 2005. [Nerium oleander self poisoning treated with digoxin-specific antibodies]. Ann. Fr. Anesth. Reanim. 24(6):640-2.
5. Borsutzky M., Passie T., Paetzold W., et al., 2002. [Hawaiian baby woodrose: (Psycho-) Pharmacological effects of the seeds of Argyreia nervosa. A case-orientated demonstration]. Nervenarzt. 73 (9):892-6.
6. Bronstein A.C., Spyker D.A., Cantilena L.R. Jr, et al., 2009. 2008 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 26th Annual Report. Clin. Toxicol. (Phila). 47(10):911-1084.
7. Carstairs S.D., Cantrell F.L., 2010. Peyote and mescaline exposures: a 12-year review of a statewide poison center database. Clin. Toxicol. (Phila). 48(4):350-3.
8. Centers for Disease Control and Prevention (CDC), 2010. Jimsonweed poisoning associated with a homemade stew - Maryland, 2008. Morb. Mortal Wkly. Rep. 59(4):102-4.
9. Chan T.Y., 2009. Aconite poisoning. Clin. Toxicol.(Phila). 47(4):279-85. Review.
10. DeFrates L.J., Hoehns J.D., Sakornbut E.L., et al., 2005. Antimuscarinic intoxication resulting from the ingestion of moonflower seeds. Ann. Pharmacother. 39(1):173-6
11. Diker D., Markovitz D., Rothman M., et al., 2007. Coma as a presenting sign of Datura stramonium seed tea poisoning. Europ. J. Int. Med. 18, 336–338
12. Eddleston M., Warrell D.A., 1999. Management of acute yellow oleander poisoning. QJM 92; 483
13. Eddleston M., Persson H., 2003. Acute plant poisoning and antitoxin antibodies. J. Toxicol. Clin. Toxicol. 41, 309–315
14. Eddleston M., Senarathna L., Mohamed F., et al., 2003. Deaths due to absence of an affordable antitoxin for plant poisoning. Lancet. 362(9389):1041-4.
15. Finkelstein Y., Aks S.E., Hutson J.R., et al., 2010. Colchicine poisoning: the dark side of an ancient drug. Clin. Toxicol. (Phila) 48(5):407-14. Review.
16. Frohne D., Pfander H.J., McKinney P., et al, 2005. Poisonous Plants: A Handbook for Doctors, Pharmacists, Toxicologists, Biologists and Veterinarians. Timber Press, Incorporated; 2 edition

17. Forrester M.B., 2006. Jimsonweed (Datura stramonium) exposures in Texas, 1998-2004. J. Toxicol. Environ. Health A. 69(19):1757-62.

18. Fujita Y., Terui K., Fujita M., et al., 2007. Five cases of Aconite Poisoning: Toxicokinetics of Aconitines. Journal of analytical Toxicology, Vol 31, 132–137

19. Galea S., Nandi A., Vlahov D., 2004. The social epidemiology of substance use. Epidemiol. Rev. 26:36-52.

20. Göpel C., Maras A., Schmidt M.H., 2003. [Hawaiian baby rose wood: case report of an argyreia nervosa induced toxic psychosis]. Psychiatr. Prax. 30(4):223-4.

21. Gottignies P., El Hor T., Tameze J.K., et al., 2009. Successful treatment of monkshood (aconitum napellus) poisoning with magnesium sulfate. Am. J. Em. Med. 27(6), 755 e1–4

22. Grobosch T., Binscheck T., Martens F., et al., 2008. Accidental intoxication with Veratrum album. J. Anal. Toxicol. 32(9):768-773

23. Haidvogl M., Fritsch G., Grubbauer HM., 1979. [Acute poisoning with green beans (phaseolus vulgaris and phaseolus coccineus) (author's transl)] Padiatr. Padol. 14(3):293-6.

24. Handeland K., 2008. Acute yew (Taxus) poisoning in moose (Alces alces). Toxicon 52(7):829-32.

25. Hoffman R.S., 2007. Understanding the limitations of retrospective analyses of poison centre data. Clin. Toxicol. (Phila). 45 (8):943-5.

26. Honey B.L., Hagemann T.M., Lobb K.M., et al., 2009. Jimson weed abuse in an Oklahoma teen. J. Okla. State Med. Assoc. 102(12):351-3.

27. Isbister G.K., Oakley P., Dawson A.H., et al., 2003. Presumed Angel's trumpet (Brugmansia) poisoning: clinical effects and epidemiology. Emerg. Med. (Fremantle). 15(4):376-82.

28. Jaspersen-Schib R., Theus L., Guirguis-Oeschger M., et al., 1996. [Serious plant poisonings in Switzerland 1966-1994. Case analysis from the Swiss Toxicology Information Centre]. Schweiz. Med. Wochenschr. 126(25): 1085-98.

29. Joshi P., Wicks A.C., Munshi S.K., 2003. Recurrent autumnal psychosis. Postgrad. Med. J. 79: 239-240

30. Kimura I., Takada M., Nojima H., 1997. Aconitine induces bradycardia through a transmission pathway including the anterior hypothalamus in conscious mice. Biol. Pharm. Bull. 20: 856

31. Krenzelok E.P., 2010a. Aspects of Datura poisoning and treatment, Clin. Toxicol. (Phila). 48(2), 104-110

32. Krenzelok E.P., 2010b. Datura poisoning and the use of physostigmine. Clin. Toxicol. (Phila). [Epub ahead of print]

33. Kupferschmidt H., 2009, Annual Report 2008, Schweizerisches Toxikologisches Informationszentrum

34. Kupper J., Reichert C., 2009. Vergiftungen mit Pflanzen. Ther. Umschau, 66:343–348

35. Lamminpää A., Kinos M., 1996. Plant poisonings in children. Hum. Exp. Toxicol. 15(3):245-9.

36. Liechti ME, Kupferschmidt H., 2004. Gamma-hydroxybutyrate (GHB) and gamma-butyrolactone (GBL): analysis of overdose cases reported to the Swiss Toxicological Information Centre. Swiss Med Wkly.;134(35-36):534-7.

37. Lin T.J., Nelson L.S., Tsai J.L., et al., 2009. Common toxidromes of plant poisonings in Taiwan. Clin. Toxicol. (Phila). 47(2):161-8.

38. Lurie Y., Fainmesser P., Yosef M., et al., 2008. Remote Identification of Poisonous Plants by Cell-Phone Camera and Online Communication. IMAJ 10:802–803

39. Mullins M.E., Carrico E.A., Horowitz B.Z., 2000. Fatal cardiovascular collapse following acute colchicine ingestion. J. Toxicol. Clin. Toxicol. 38, 51-54

40. Musajo L., Rodighiero G., 1970. Studies on the photo-C4-cyclo-addition reactions between skin-photosensitizing furocoumarins and nucleic acids. Photochem. Photobiol. 11(1):27-35.

41. Papoutsis I., Nikolaou P., Athanaselis S., et al., 2010. Mass intoxication with Datura innoxia--case series and confirmation by analytical toxicology. Clin. Toxicol. (Phila). 48(2):143-5.

42. Persson H.E., Sjöberg G.K., Haines J.A., et al.,1998. Poisoning Severity Score. Grading of acute poisoning. J. Toxicol. Clin. Toxicol. 36: 205-13

43. Piccillo G.A., Miele L., Mondati E., et al., 2006. Anticholinergic syndrome due to "Devil's Herb": when risks come from the ancient time. Int. J. Clin. Pract. 60, 4, 492–494

44. Pietsch J., Schulz K., Schmidt U., et al., 2007. A comparative study of five fatal cases of Taxus poisoning. Int. J. Legal. Med. 121(5):417-22.

45. Pietsch J., Koch I., Hermanns-Clausen M., et al., 2008. Paediatric plant exposures in Germany, 1998-2004. Clin. Toxicol. (Phila) 46(7):686-91.

46. Pietsch J., Oertel R., Trautmann S., et al., 2005. A non-fatal oleander poisoning. Int. J. Legal. Med. 119(4):236-40.

47. Phillip J., Lichius-Brich A., 2005. Typical autumn poisoning. Trouble when the pumpkin tastes bitter. MMW Fortschr. Med. 147(43):10-1.

48. Pullela R., Young L., Gallagher B., et al., 2008. A case of fatal Aconitine Poisoning by Monkshood ingestion. J. Forensic Sc. Vol 53, No 2, 491–494

49. Smith S.W., Giesbrecht E., Thompson M., et al., 2008. Solanaceous steroidal glycoalkaloids and poisoning by Solanum torvum, the normally edible susumber berry. Toxicon 52(6):667-76.

50. Spina S.P., Taddei A., 2007. Teenagers with Jimson weed (Datura stramonium) poisoning. CJEM. 9(6):467-8.

51. Srivastava A., Peshin S.S., Kaleekal T., et al., 2005. An epidemiological study of poisoning cases reported to the National Poisons Information Centre. All India Institute of Medical Sciences, New Delhi. Hum. Exp. Toxicol. 24(6):279-85.

52. Strzelecki A., Pichon N., Gaulier J.M., et al., 2010. Acute Toxic Herbal Intake in a Suicide Attempt and Fatal Refractory Ventricular Arrhythmia. Basic Clin. Pharmacol. Toxicol. 107(2):698-9.

53. Sundov Z., Nincevic Z., Definis-Gojanovic M., et al., 2005. Fatal colchicine poisoning by accidental ingestion of meadow saffron: a case report. Forensic Science International, 149, 253–256

54. Teuscher E., Lindequist U., 1994. Biogene Gifte. Gustav Fischer Verlag, Stuttgart, Jena, New York

55. Tuchman E., 2010. Women and addiction: the importance of gender issues in substance abuse research. J. Addict. Dis. 29(2):127-38.

56. Vichova P., Jahodar L., 2003. Plant poisonings in children in the Czech Republic, 1996-2001. Hum. Exp. Toxicol. 22(9):467-72.

57. Wasfi I.A., Zorob O., Al Katheeri N.A., et al., 2008. A fatal case of oleandrin poisoning. Forensic Science International 179, e31–e36

58. Wiebe T.H., Sigurdson E.S., Katz L.Y., 2008. Angel's Trumpet (Datura stramonium) poisoning and delirium in adolescents in Winnipeg, Manitoba: Summer 2006. Paediatr. Child Health 13(3):193-6.

59. Willaert W., Claessens P., Vankelecom B., et al., 2002. Intoxication with Taxus Baccata: Cardiac arrhythmias following yew leaves ingestion. PACE Vol 25, NO 4 Part 1, 511–512

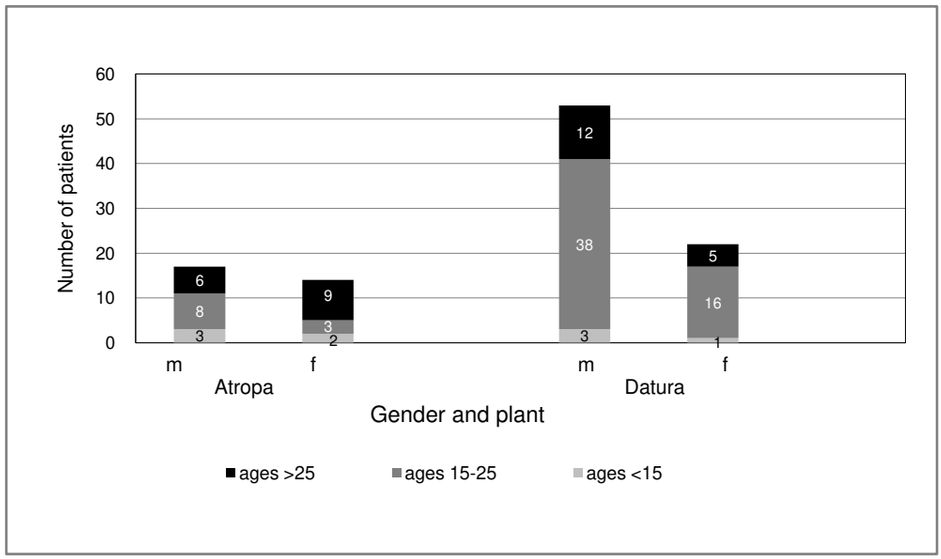
60. Wollersen H., Erdmann F., Risse M., et al., 2009. Accidental fatal ingestion of colchicine-containing leaves: toxicological and histological findings. Legal Medicine 11, Suppl 1, 498–499

61. Zilberman M., Tavares H., el-Guebaly N., 2003. Gender similarities and differences: the prevalence and course of alcohol- and other substance-related disorders. J. Addict. Dis. 22(4):61-74.

62. Zilker Th., 2008. Giftnotruf München, Annual Report 2006/2007

Figure

3	2	3	1
8	3	38	16
6	9	12	5



Figure

Fig. 1 Intoxications due to abuse by ingestion of Atropa belladonna and Datura sp

Table 1

Symptoms and severity of intoxications

Organ System	minor	moderate	severe
Nervous system	Somnolence, dizziness, tremor, restlessness, drowsiness, tinnitus, ataxia, mild anticholinergic symptoms (dry mouth, mydriasis)	Unconsciousness with appropriate response to pain (GCS[a] 8-9), agitation, single generalized or local seizures, myoclonia, hallucinations	Deep coma with inappropriate response to pain or unresponsive to pain (GCS[a] ≤7), multiple generalized seizures, psychosis, delirium
Cardiovascular system	Mild ECG[b] changes (QTc[c] >390ms ♂, >440ms ♀; extra systoles, right bundle branch block) Tachycardia (100-139 bpm) Hypotension (80-100 mmHg)	Moderate ECG[b] changes (QTc[c] >430ms ♂, >485ms ♀; AV[d] block I° and II°) Tachycardia (140-179 bpm) Hypotension (55-79 mmHg) Bradycardia (40-50 bpm)	AV[d] block III°, life-threatening ventricular dysrhythmias, Tachycardia (>180 bpm) Hypotension (<55 mmHg) Bradycardia (<40 bpm)
Gastrointestinal tract	Vomiting, nausea, occasional diarrhea, pain	Pronounced or prolonged vomiting, prolonged diarrhea, pain, ileus, intestinal atonia	bloody diarrhea, perforations
Skin	Erythema	Burns grade 2a-b, small surface	Burns grade 2b-3, or grade 2b large surface
Eyes	Conjunctivitis	Corneal erosion, Corneal inclusions	Corneal lesion of large size or permanent nature

[a]Glasgow Coma Scale score; [b]Electrocardiogram; [c]QT interval corrected for heart rate; [d]Atrioventricular.

Table 2

50 most frequent plant genera involved in human contact cases with potentially toxic plants

Plant Genus	Cases	Adults	Children	Accidental	Abuse	Suicidal
Prunus	2966	207	2756	2962	1	3
Ficus	1801	126	1675	1795	1	3
Taxus	1750	232	1513	1678	5	61
Euphorbia	1515	687	822	1497	9	9
Convallaria	1282	168	1108	1272		7
Lonicera	988	23	965	985		
Cotoneaster	941	14	926	941		
Physalis	840	88	752	839	1	
Datura	698	490	205	371	290	30
Mahonia	691	8	683	690		
Solanum	675	159	514	672		3
Ligustrum	634	14	620	632		1
Hedera	628	53	574	625	1	2
Sambucus	576	169	401	575		1
Sorbus	535	27	508	529		4
Dieffenbachia	519	108	408	517		2
Allium	464	374	72	463		1
Viburnum	448	33	415	446		
Viscum	426	19	406	421		1
Cornus	364	20	343	362		
Ilex	361	38	323	359		2
Phaseolus	358	160	190	358		
Nerium	353	108	244	333	3	17
Capsicum	351	200	150	351		
Zamioculcas	349	16	333	349		
Spathiphyllum	344	8	336	344		
Cucurbita	330	261	66	330		
Narcissus	330	114	178	330		
Atropa	315	159	156	213	69	29
Thuja	303	69	234	293	3	3
Tulipa	292	63	224	290		2
Yucca	290	27	263	290		
Pyracantha	281	62	219	280		1
Duchsenea	240	25	215	240		
Colchicum	231	127	99	212		8
Heracleum	218	130	87	217		
Euonymus	207	16	191	201	1	5
Berberis	186	48	134	183		1
Muscari	186	10	174	185		
Crocus	181	24	157	174		7
Quercus	174	14	160	174		
Aesculus	168	36	132	168		
Schefflera	167	7	159	166		
Ranunculus	163	18	145	162		
Wisteria	155	17	138	155		
Parthenocissus	154	7	147	154		
Epipremnum	154	6	148	153		
Symphoricarpos	153	1	152	153		
Berries unspecif.	3346	118	3228	3319		5
Plants unspecif.	1419	334	1082	1360	33	11
Total	30499	5240	25177	29770	417	219

Table 3
Plants mostly responsible for moderate symptoms:

Latin Name	Common Name	Number of cases
Datura suaveolens	Angel's Trumpet	36
Atropa belladonna	Deadly nightshade	26
Euphorbia sp	Euphorbia	22
Heracleum mantegazzianum	Giant Hogweed	16
Datura stramonium	Jimson Weed	15
Cucurbita pepo	Pumpkins	11
Phaseolus sp	Beans	6
Argyreia nervosa	Hawaiian Baby Woodrose	5
Allium ursinum	Bear's Garlic	4
Ricinus communis	Castor bean	4
Wisteria floribunda	Wisteria	4
Taxus baccata	Yew	4
Datura sp	Datura	3
Colchicum autumnale	Meadow saffron	3
Daphne mezereum	Daphne	3
Phytolacca americana	Pokeweed	3
Lycopodium	Club Moss	3
Cactaceae	Cactus	3
6 different plants		2
25 different plants		1

Table 4

Cases with severe and lethal outcomes

Age in years (if not otherwise stated)	Plant	Symptoms	Treatment	Causality	Outcome
Adult	Euphorbia sp	Extensive corneal lesion	Contact lens, Neosporin-Eye-drops	Probable	Restitution
47	Euphorbia sp	Corneal lesion	Ofloxacine drops	Probable	Visus reduction
39	Prunus spinosa	Suspected vasovagal reaction with bradycardia and hypotension	Steroids, antihistaminics	Probable	Restitution
Child	Heracleum mantegazzianum	Photodermatitis (legs, arms, face)	None	Probable	Restitution
2 months	Illicium anisatum	Seizures, nystagmus	None	Confirmed	Restitution
52	Cucurbita pepo	Hemorrhagic diarrhea	Metoclopramide, hydration	Probable	Restitution
72	Cucurbita pepo	Massive bloody diarrhea	Hydration	Probable	Restitution
30	Phaseolus sp	Massive vomiting and diarrhea	Hydration	Probable	Restitution
44	Phaseolus sp	Massive vomiting and diarrhea	Hydration	Probable	Restitution
1.5	Atropa belladonna	Apathy, tachycardia	Physostigmine, activated charcoal	Probable	Restitution
3	Atropa belladonna	Vomiting, tachycardia	Physostigmine, activated charcoal	Probable	Restitution
34	Atropa belladonna	Agitation, mydriasis, tachycardia	Physostigmine, Benzodiazepines	Probable	Restitution
35	Atropa belladonna	Agitation, mydriasis, tachycardia	Physostigmine, activated charcoal	Probable	Restitution
65	Atropa belladonna	Mydriasis, psychosis, dry skin	None	Probable	Restitution
18	Datura sp.	Delirium, mydriasis, tachycardia	Benzodiazepines	Probable	Restitution
3	Datura suaveolens	Mydriasis, hallucinations, tachycardia, agitation	Activated charcoal, Benzodiazepines	Probable	Restitution
4	Datura suaveolens	Mydriasis, hallucinations, tachycardia, agitation	Benzodiazepines	Probable	Restitution

17	Datura suaveolens	Hallucinations, seizures, mydriasis, paralytic ileus, RBBB	Benzodiazepines, Physostigmine	Probable	Restitution
17	Datura suaveolens	Agitation, urine retention, tachycardia	Physostigmine	Probable	Restitution
17	Datura suaveolens	Delirium, mydriasis, tachycardia	Physostigmine, Benzodiazepines	Probable	Restitution
18	Datura suaveolens	Agitation, hallucinations, tachycardia	Physostigmine, Benzodiazepines	Probable	Restitution
18	Datura suaveolens	Hallucinations, agitation, disorientation, mydriasis	Activated charcoal, Benzodiazepines	Probable	Restitution
18	Datura suaveolens	Hallucinations, agitation, dyspnea	Physostigmine, Benzodiazepines	Probable	Restitution
20	Datura suaveolens	Hallucinations, agitation, disorientation, mydriasis	Benzodiazepines, Physostigmine	Probable	Restitution
21	Datura suaveolens	Severe agitation, mydriasis	Benzodiazepines, Physostigmine	Probable	Restitution
21	Datura suaveolens	Agitation, mydriasis, tachycardia, delirium	Physostigmine, Benzodiazepines	Probable	Restitution
22	Datura suaveolens	Severe agitation, mydriasis, hallucinations	Physostigmine, Haloperidol	Probable	Restitution
26	Datura suaveolens	Agitation, hallucinations, tachycardia	Physostigmine, Benzodiazepines	Probable	Restitution
Adult	Datura suaveolens	Bradycardia, mydriasis, delirium	None	Probable	Restitution
Adult	Datura suaveolens	Somnolence, respiratory depression	Activated charcoal, intubation	Probable	Restitution
14	Datura stramonium	Confusion, tachycardia, mydriasis	Physostigmine	Probable	Restitution
17	Datura stramonium	Agitation, tachycardia	Physostigmine, Benzodiazepines	Probable	Restitution
20	Datura stramonium	Mydriasis, hallucinations, tachycardia, confusion	Prostigmine, Benzodiazepines	Probable	Restitution
23	Datura stramonium	Severe hallucinations, mydriasis	Benzodiazepines	Probable	Restitution
32	Datura stramonium	Mydriasis, hallucinations, agitation	Physostigmine	Probable	Restitution
18	Mandragora officinalis	Coma, anticholinergic syndrome	None	Probable	Restitution
20	Ipomoea purpurea	Panic	Benzodiazepines	Probable	Restitution
41	Nerium oleander	Bradycardia, SA-block, vomiting	Activated charcoal	Confirmed	Restitution
25	Aconitum napellus	Paresthesias, GI-Symptoms, bradycardia, urinary	Atropine	Probable	Restitution

		retention			
36	Aconitum napellus	Hypotension, ventricular tachycardia, paresthesias	Multiple dose activated charcoal, Lidocaine, Magnesiumsulfate	Probable	Restitution
47	Aconitum napellus	Ventricular fibrillation, bigeminus, hypotonia, vomiting	Defibrillation, Magnesiumsulfate	Confirmed	Restitution
69	Aconitum napellus	Agitation, repetitive ventricular tachycardia, hypothermia, arrhythmia	Multiple dose activated charcoal, Defibrillation, Amiodarone	Probable	Restitution
adult	Aconitum napellus	Seizures, vomiting, bigeminus, ventricular fibrillation	Magnesiumsulfate, Catecholamines	Probable	Restitution
45	Veratrum album	Bradycardia, hypotension	None	Probable	Restitution
59	Veratrum album	Diarrhea, vomiting, hypotension, bradycardia	Activated charcoal, supportive therapy	Probable	Restitution
44	Taxus baccata	Tachycardia, bradycardia, AV-Block III°, asystolia	Activated charcoal, Atropine, Magnesium, Catecholamines, Pacemaker, Defibrillation	Probable	Fatal
3	Colchicum autumnale	Bradycardia, cerebral edema, vomiting, seizures, respiratory and hepatic failure	Supportive therapy	Confirmed	Fatal
57	Colchicum autumnale	Pulmonary edema, arrhythmia, coagulopathy, renal failure	Multiple dose activated charcoal, supportive therapy	Confirmed	Fatal
62	Colchicum autumnale	Renal failure, necrosis of the heart muscle, coagulopathy	Multiple dose activated charcoal, supportive therapy	Confirmed	Fatal

RBBB= right bundle branch block; SA-block= Sinoatrial block; AV-block= Atrioventricular block; GI-Symptoms= gastro-intestinal symptoms